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Ando et al.

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(45) **Date of Patent: Aug. 25, 2015**

(54) **WIRELESS COMMUNICATION TERMINAL, WIRELESS COMMUNICATION DEVICE, AND WIRELESS COMMUNICATION METHOD**

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H04W 4/02 (2009.01)

(52) **U.S. Cl.**
CPC ***H04W 4/008*** (2013.01); ***H04W 4/021*** (2013.01); ***H04W 4/023*** (2013.01)

(58) **Field of Classification Search**
CPC H04W 4/021
USPC 455/41.1, 41.2, 41.3
See application file for complete search history.

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(74) *Attorney, Agent, or Firm* — Seed IP Law Group PLLC

(57) **ABSTRACT**

A master device transmits a beacon signal including information related to a proximity wireless communication area in a predetermined cycle by using a transmission power which allows the beacon signal to reach beyond the proximity wireless communication area. When a slave device receives the beacon signal from the master device, the slave device estimates a distance to the master device in accordance with the information of the beacon signal. When a wireless communication terminal is located within the proximity wireless communication area, the slave device is connected to the master device by using a proximity wireless communication.

10 Claims, 10 Drawing Sheets

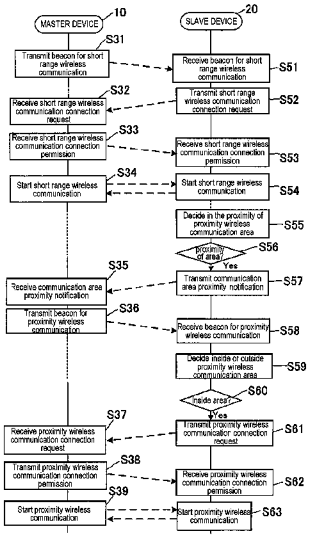
MASTER DEVICE
10
SLAVE DEVICE
20
S31
Transmit beacon for short range wireless communication
Receive beacon for short range wireless communication
S51
S32
Receive short range wireless communication connection request
Transmit short range wireless communication connection request
S52
S33
Receive short range wireless communication connection permission
Receive short range wireless communication connection permission
S53
S34
Start short range wireless communication
Start short range wireless communication
S54
Decide in the proximity of proximity wireless communication area
S55
proximity of area?
S56
Yes
S35
Receive communication area proximity notification
Transmit communication area proximity notification
S57
S36
Transmit beacon for proximity wireless communication
Receive beacon for proximity wireless communication
S58
Decide inside or outside proximity wireless communication area
S59
Inside area?
S60
Yes
S37
Receive proximity wireless communication connection request
Transmit proximity wireless communication connection request
S61
S38
Transmit proximity wireless communication connection permission
Receive proximity wireless communication connection permission
S62
S39
Start proximity wireless communication
Start proximity wireless communication
S63

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FIG.1

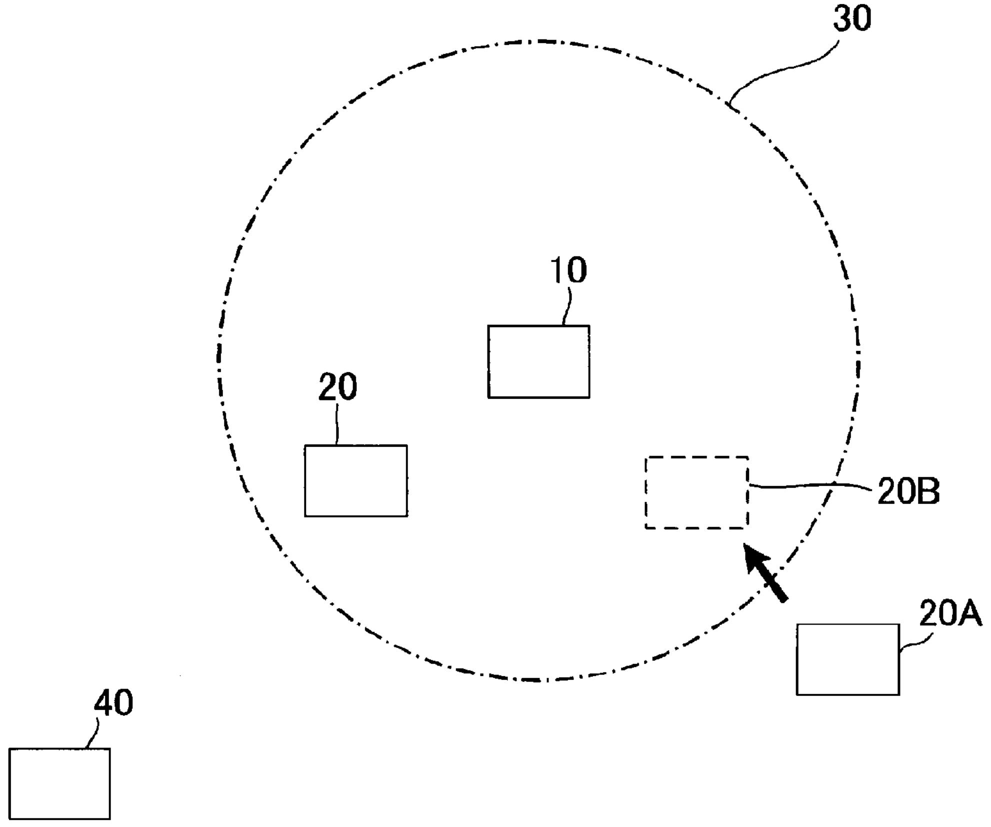

30
10
20
20B
20A
40

FIG.2

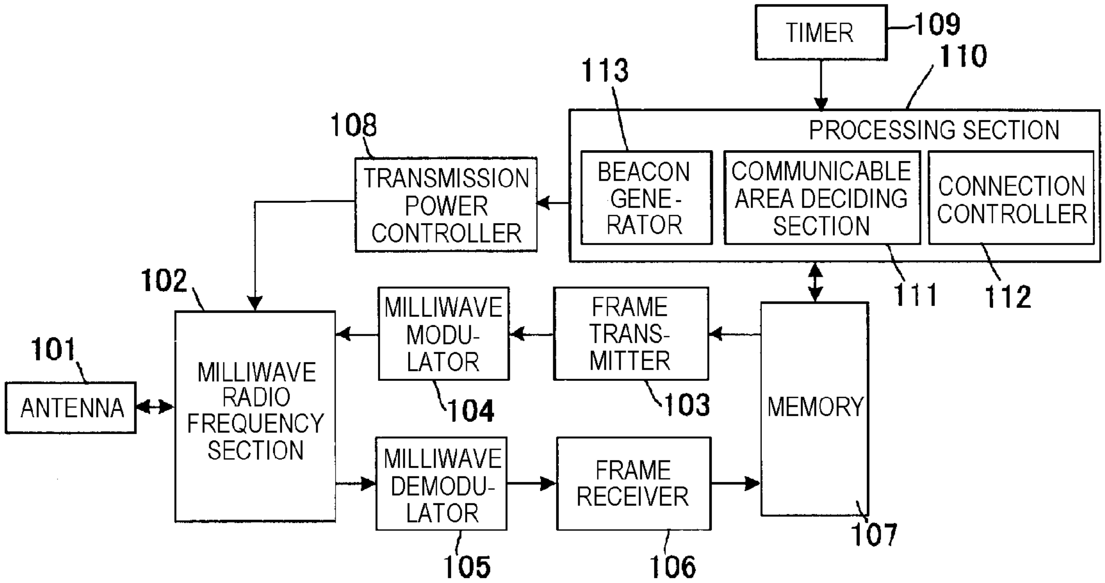

TIMER
109
110
113
PROCESSING SECTION
108
BEACON GENERATOR
COMMUNICABLE AREA DECIDING SECTION
CONNECTION CONTROLLER
TRANSMISSION POWER CONTROLLER
102
111
112
MILLIWAVE MODULATOR
FRAME TRANSMITTER
101
MILLIWAVE RADIO FREQUENCY SECTION
ANTENNA
104
103
MEMORY
MILLIWAVE DEMODULATOR
FRAME RECEIVER
107
105
106

FIG.3

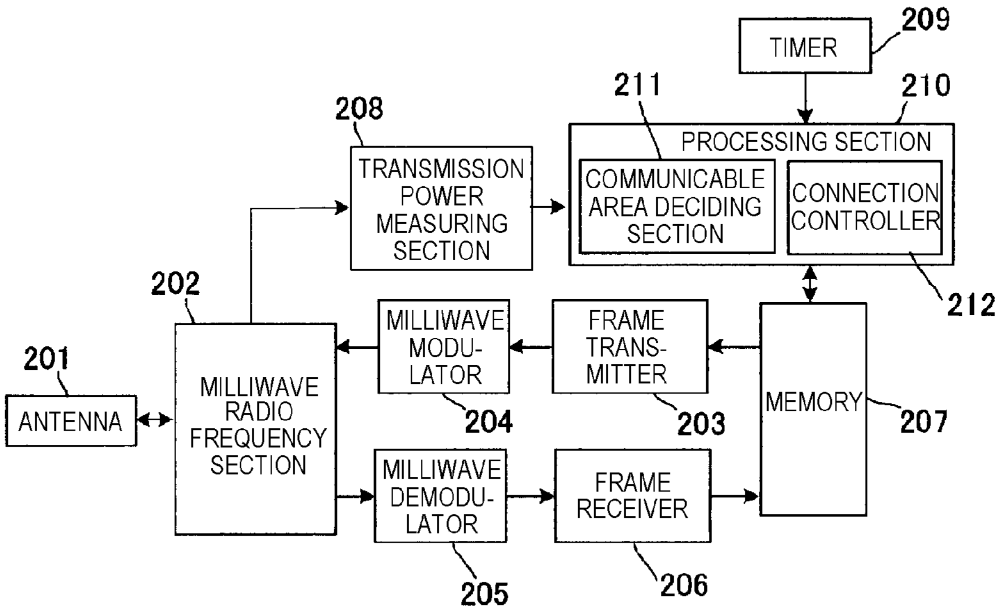

TIMER
209
211
210
208
PROCESSING SECTION
TRANSMISSION POWER MEASURING SECTION
COMMUNICABLE AREA DECIDING SECTION
CONNECTION CONTROLLER
202
212
MILLIWAVE MODULATOR
FRAME TRANSMITTER
201
MILLIWAVE RADIO FREQUENCY SECTION
MEMORY
207
ANTENNA
204
203
MILLIWAVE DEMODULATOR
FRAME RECEIVER
205
206

FIG. 4

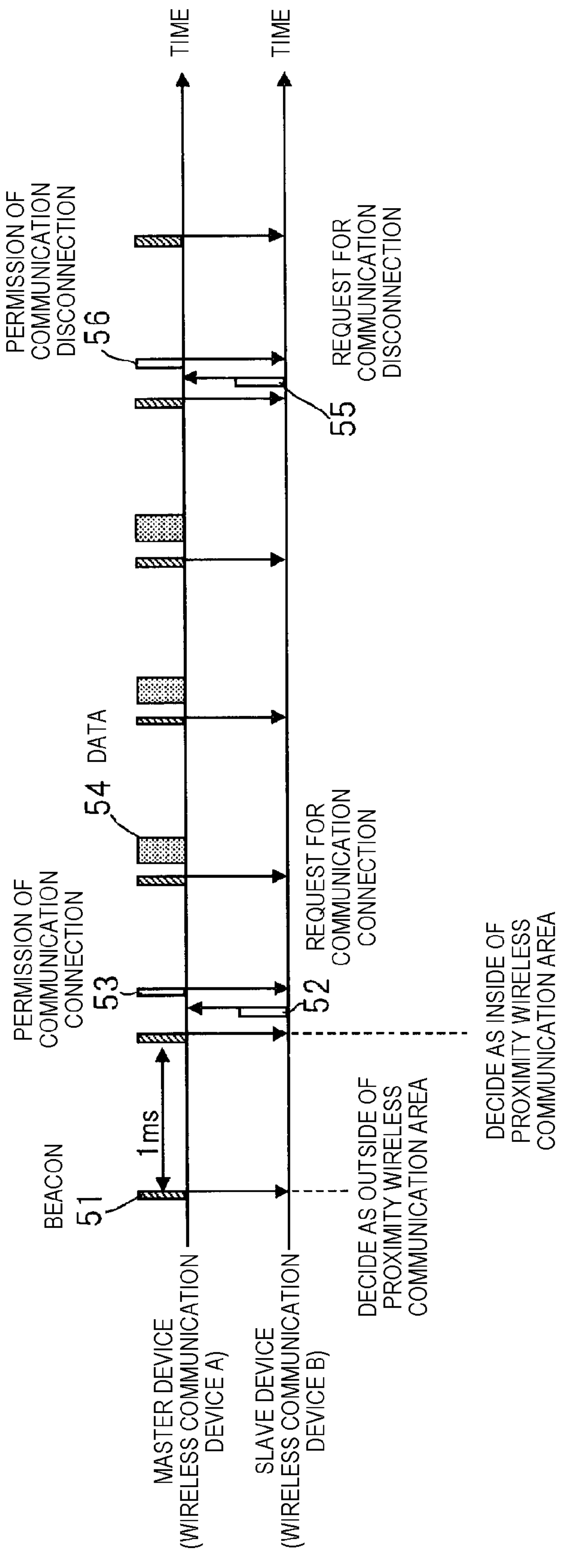

MASTER DEVICE (WIRELESS COMMUNICATION DEVICE A)
SLAVE DEVICE (WIRELESS COMMUNICATION DEVICE B)
BEACON
51
1ms
DECIDE AS OUTSIDE OF PROXIMITY WIRELESS COMMUNICATION AREA
DECIDE AS INSIDE OF PROXIMITY WIRELESS COMMUNICATION AREA
PERMISSION OF COMMUNICATION CONNECTION
53
52
REQUEST FOR COMMUNICATION CONNECTION
54
DATA
55
REQUEST FOR COMMUNICATION DISCONNECTION
56
PERMISSION OF COMMUNICATION DISCONNECTION
TIME
TIME

FIG. 5

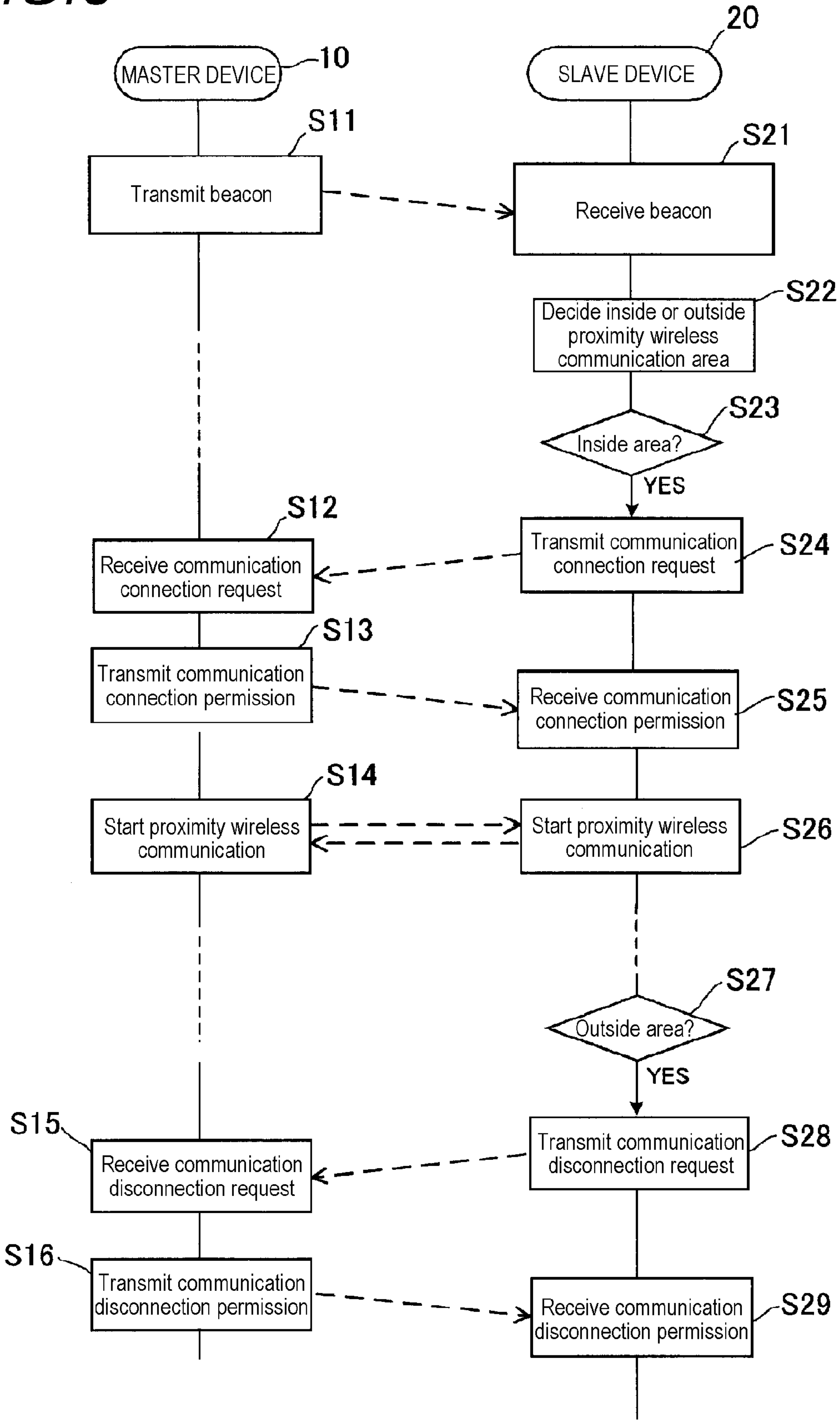

MASTER DEVICE
10
SLAVE DEVICE
20
S11
Transmit beacon
S21
Receive beacon
S22
Decide inside or outside proximity wireless communication area
S23
Inside area?
YES
S12
Receive communication connection request
S24
Transmit communication connection request
S13
Transmit communication connection permission
S25
Receive communication connection permission
S14
Start proximity wireless communication
S26
Start proximity wireless communication
S27
Outside area?
YES
S15
Receive communication disconnection request
S28
Transmit communication disconnection request
S16
Transmit communication disconnection permission
S29
Receive communication disconnection permission

FIG.6

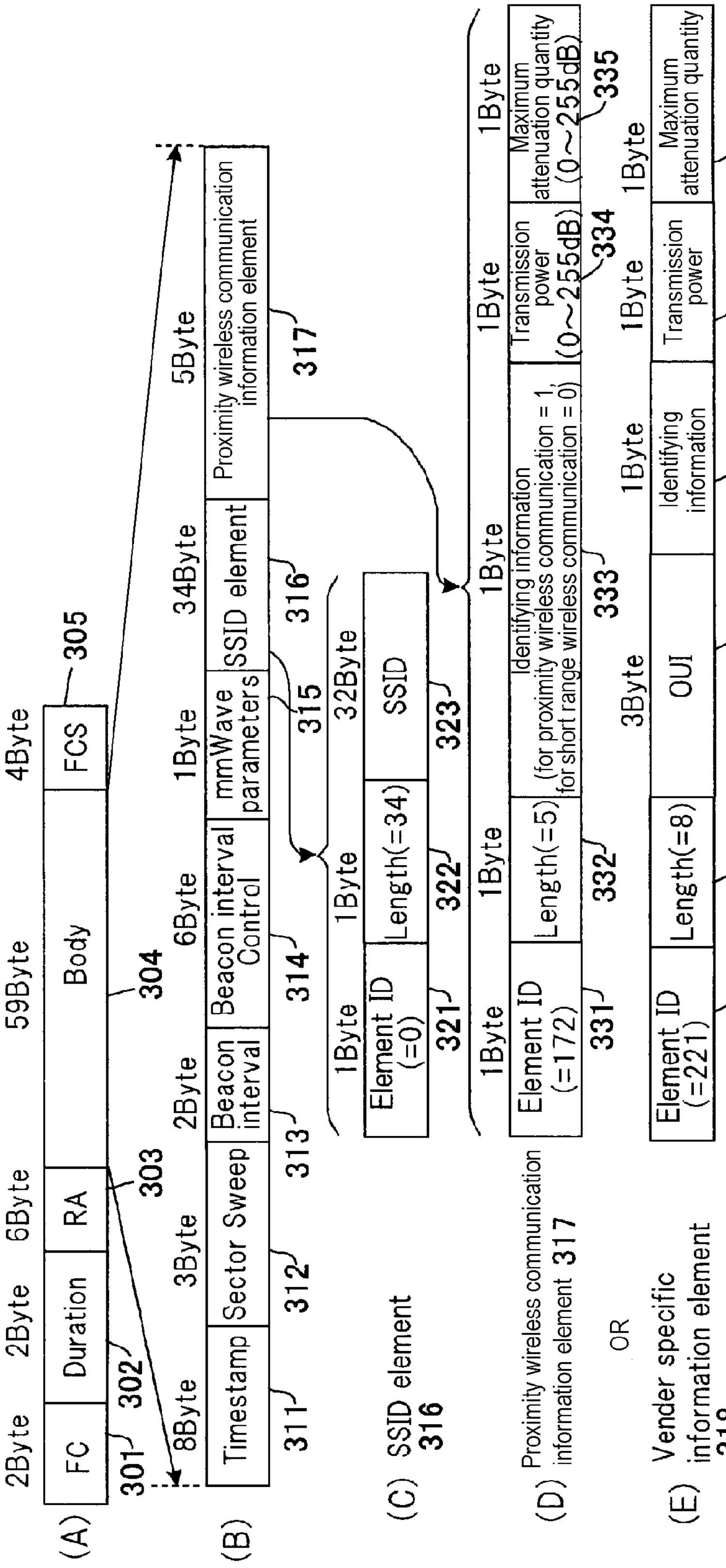

(A)
2Byte
FC
301
2Byte
Duration
302
6Byte
RA
303
59Byte
Body
304
4Byte
FCS
305
(B)
8Byte
Timestamp
311
3Byte
Sector Sweep
312
2Byte
Beacon interval
313
6Byte
Beacon interval Control
314
1Byte
mmWave parameters
315
34Byte
SSID element
316
5Byte
Proximity wireless communication information element
317
(C) SSID element 316
1Byte
Element ID (=0)
321
1Byte
Length(=34)
322
32Byte
SSID
323
(D) Proximity wireless communication information element 317
1Byte
Element ID (=172)
331
1Byte
Length(=5)
332
1Byte
Identifying information (for proximity wireless communication = 1, for short range wireless communication = 0)
333
1Byte
Transmission power (0~255dB)
334
1Byte
Maximum attenuation quantity (0~255dB)
335
OR
(E) Vender specific information element 318
Element ID (=221)
341
Length(=8)
342
3Byte
OUI
343
1Byte
Identifying information
344
1Byte
Transmission power
345
1Byte
Maximum attenuation quantity
346

FIG.7

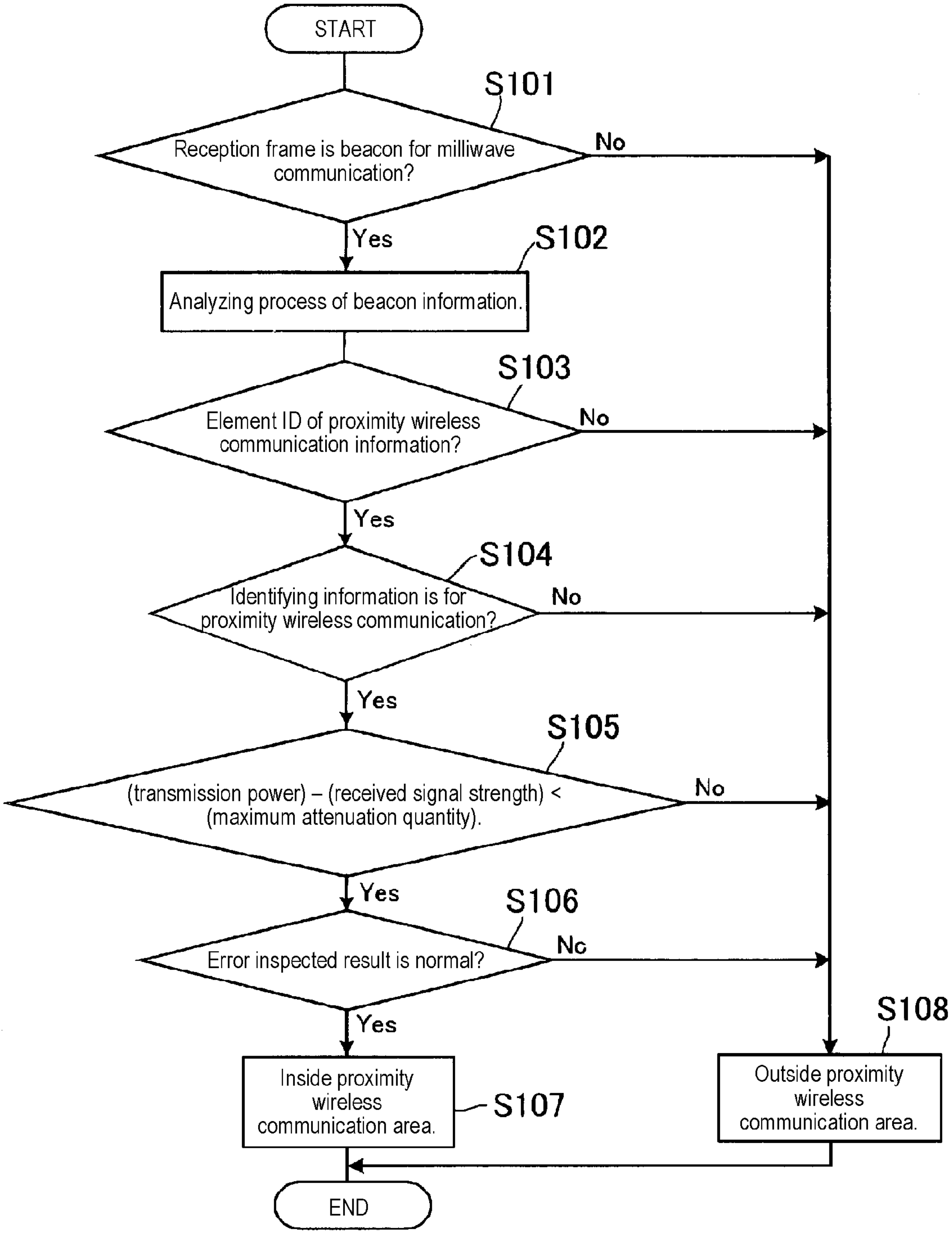

START
S101
Reception frame is beacon for milliwave communication?
No
Yes
S102
Analyzing process of beacon information.
S103
Element ID of proximity wireless communication information?
No
Yes
S104
Identifying information is for proximity wireless communication?
No
Yes
S105
(transmission power) – (received signal strength) < (maximum attenuation quantity).
No
Yes
S106
Error inspected result is normal?
No
Yes
S108
Inside proximity wireless communication area.
S107
Outside proximity wireless communication area.
END

FIG.8

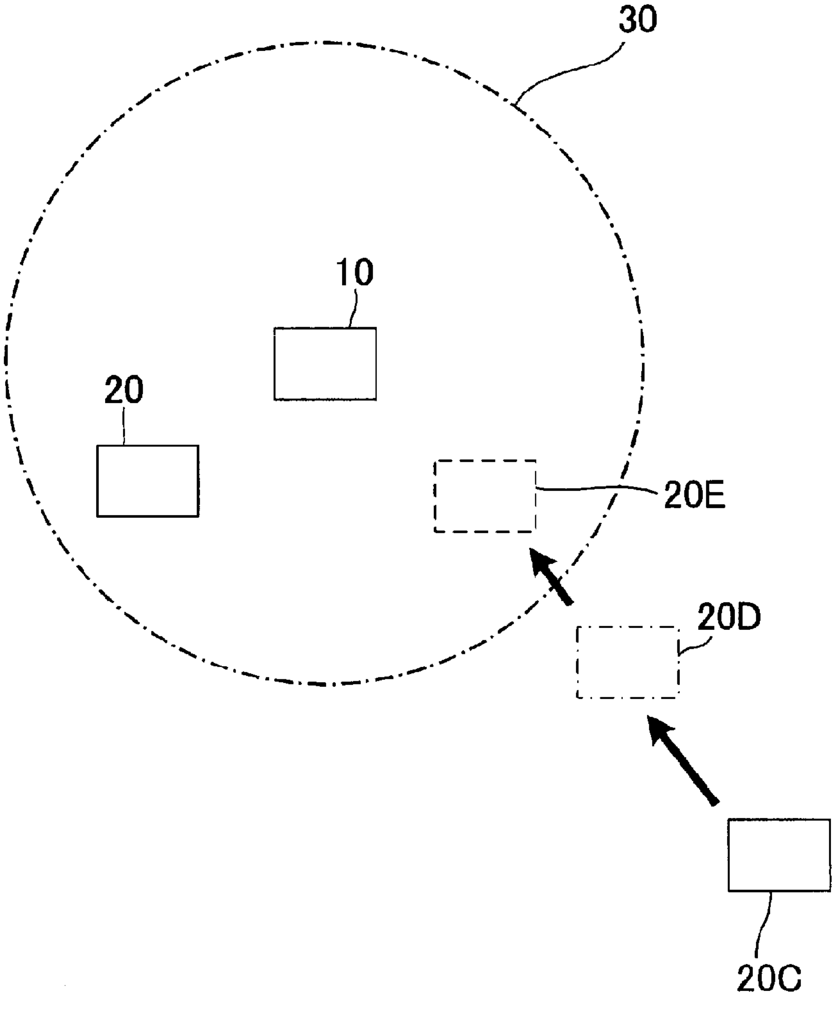

30
10
20
20E
20D
20C

FIG. 9

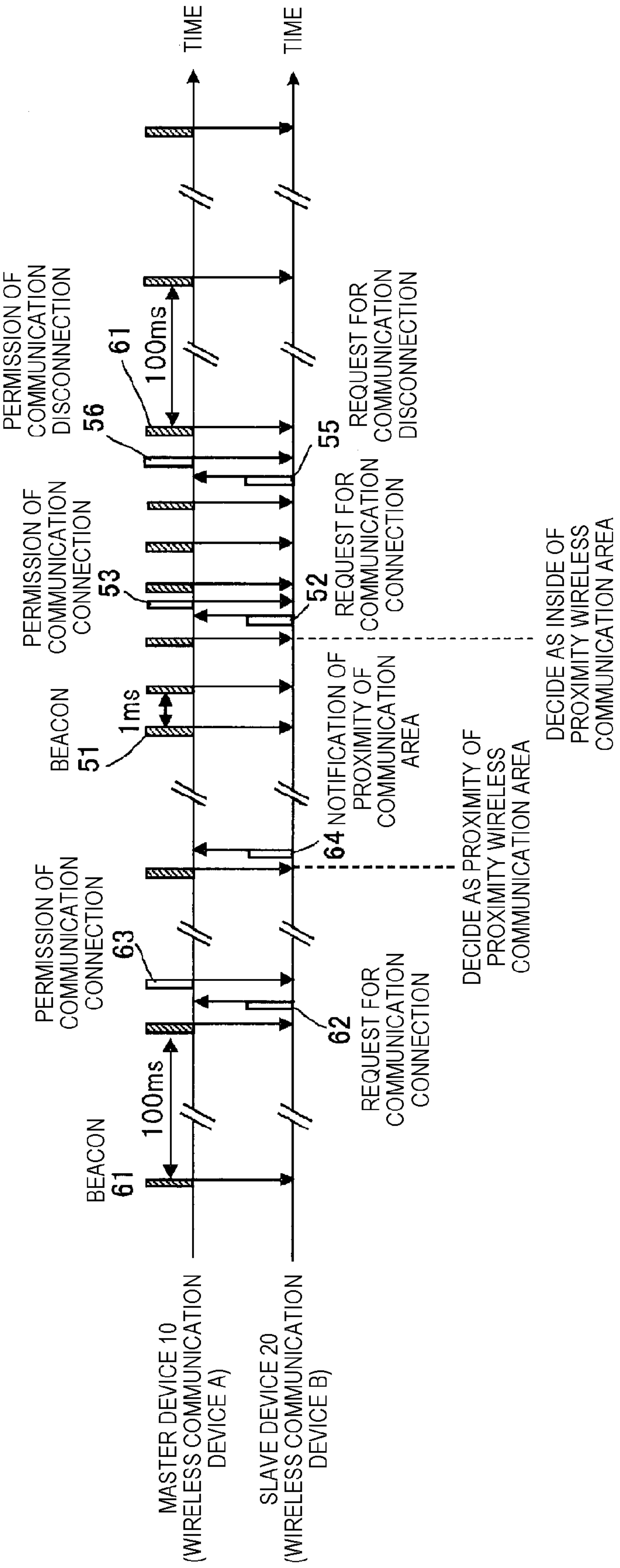

MASTER DEVICE 10 (WIRELESS COMMUNICATION DEVICE A)
SLAVE DEVICE 20 (WIRELESS COMMUNICATION DEVICE B)
BEACON 61
100ms
REQUEST FOR COMMUNICATION CONNECTION
62
PERMISSION OF COMMUNICATION CONNECTION
63
DECIDE AS PROXIMITY OF PROXIMITY WIRELESS COMMUNICATION AREA
64
NOTIFICATION OF PROXIMITY OF COMMUNICATION AREA
BEACON 51
1ms
DECIDE AS INSIDE OF PROXIMITY WIRELESS COMMUNICATION AREA
52
REQUEST FOR COMMUNICATION CONNECTION
PERMISSION OF COMMUNICATION CONNECTION
53
55
REQUEST FOR COMMUNICATION DISCONNECTION
PERMISSION OF COMMUNICATION DISCONNECTION
56
61
100ms
TIME
TIME

FIG. 10

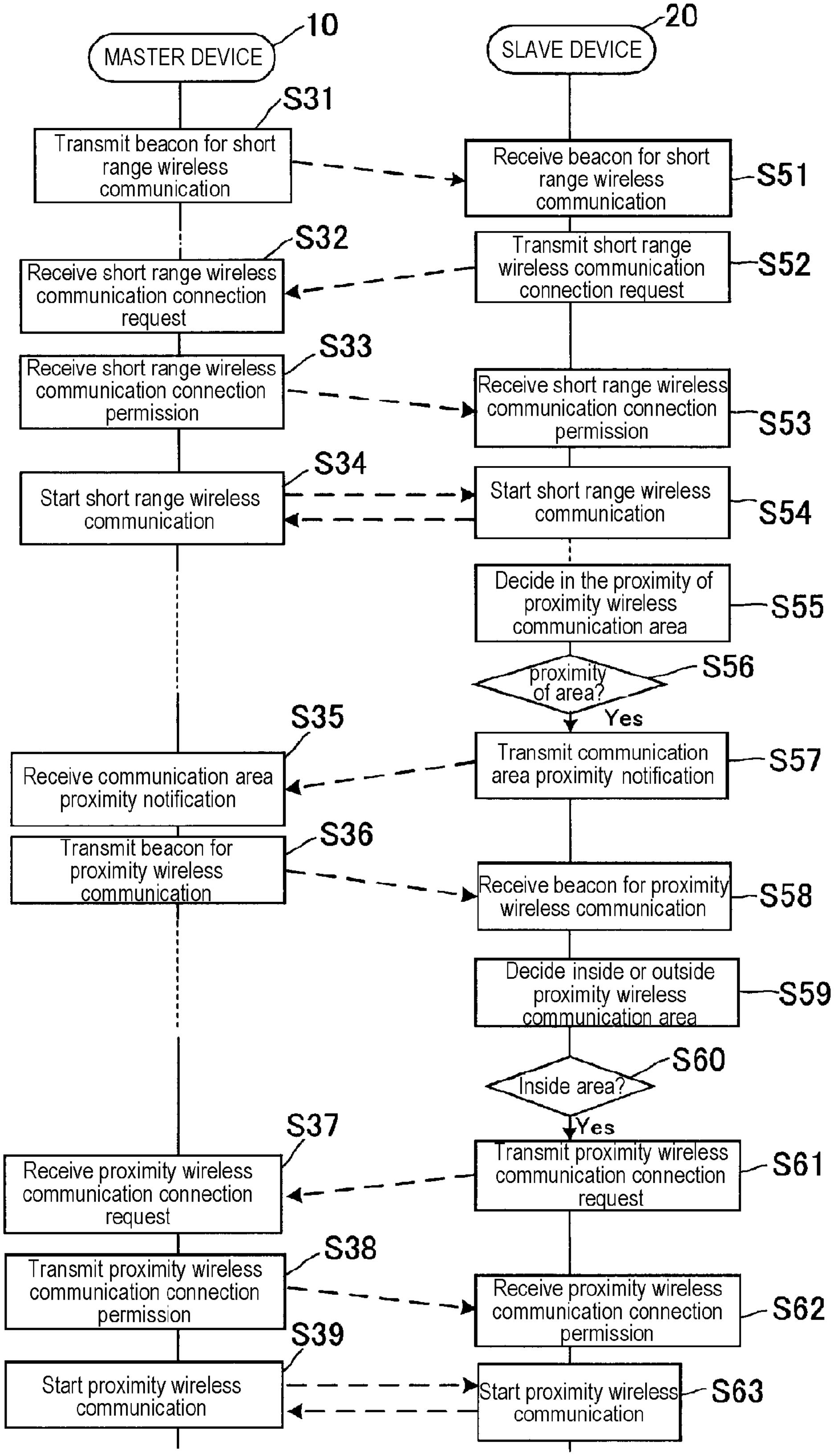

MASTER DEVICE
10
SLAVE DEVICE
20
S31
Transmit beacon for short range wireless communication
Receive beacon for short range wireless communication
S51
S32
Receive short range wireless communication connection request
Transmit short range wireless communication connection request
S52
S33
Receive short range wireless communication connection permission
Receive short range wireless communication connection permission
S53
S34
Start short range wireless communication
Start short range wireless communication
S54
Decide in the proximity of proximity wireless communication area
S55
proximity of area?
S56
Yes
S35
Receive communication area proximity notification
Transmit communication area proximity notification
S57
S36
Transmit beacon for proximity wireless communication
Receive beacon for proximity wireless communication
S58
Decide inside or outside proximity wireless communication area
S59
Inside area?
S60
Yes
S37
Receive proximity wireless communication connection request
Transmit proximity wireless communication connection request
S61
S38
Transmit proximity wireless communication connection permission
Receive proximity wireless communication connection permission
S62
S39
Start proximity wireless communication
Start proximity wireless communication
S63

FIG.11

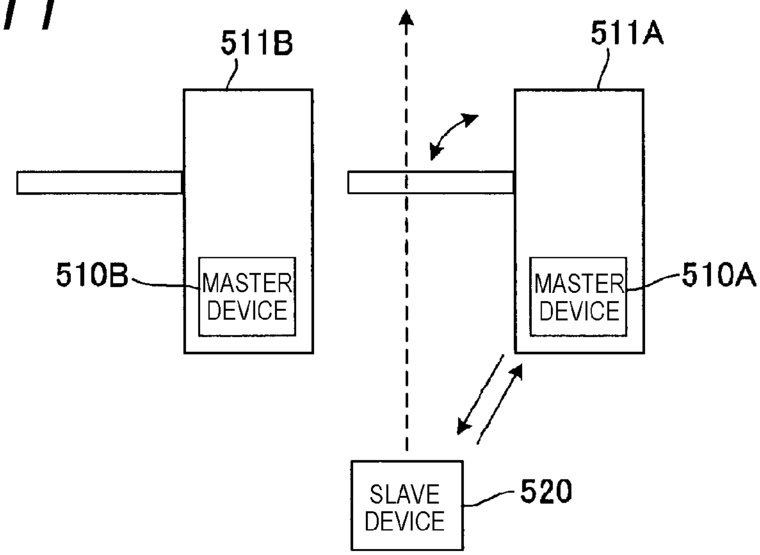

511B
511A
510B
MASTER DEVICE
MASTER DEVICE
510A
SLAVE DEVICE
520

FIG.12

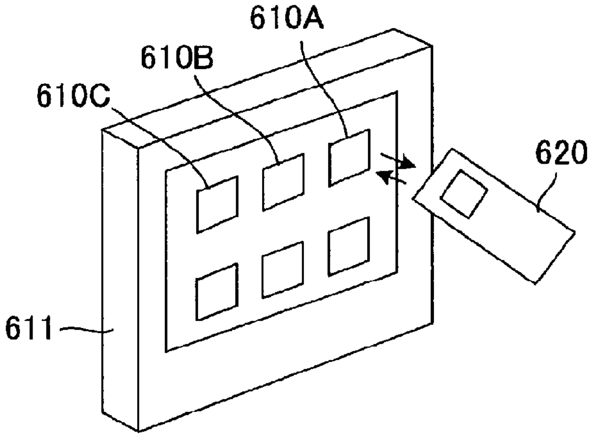
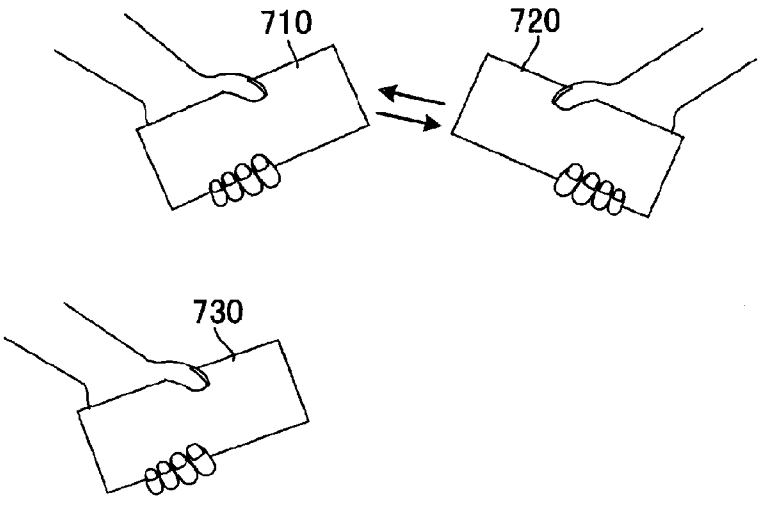

610A
610B
610C
620
611

FIG.13



WIRELESS COMMUNICATION TERMINAL, WIRELESS COMMUNICATION DEVICE, AND WIRELESS COMMUNICATION METHOD

TECHNICAL FIELD

The present invention relates to a wireless communication terminal, a wireless communication device, and a wireless communication method which can perform a proximity wireless communication between devices near to each other.

BACKGROUND ART

The proximity wireless communication serves to perform a wireless communication in a short distance such as several cm or so. For instance, for an entrance and exit in a wicket of a railway station, a payment in a register of a shop or the like, the proximity wireless communication is employed which uses a non-contact IC card and a reader/writer by, for instance, an NFC (Near Field Communication).

As the wireless communication used for an area wider than that of the proximity wireless communication, there is a short range wireless communication such as a wireless LAN. The short range wireless communication achieves the wireless communication in a short range such as several ten cm to several m or so.

In a communication system using the proximity wireless communication or the short range wireless communication, there is a possibility that a plurality of wireless communication devices (including a communication terminal, an IC card or the like) may coexist in an area of a short range, and it is one problem to prevent a wrong connection and a wrong communication between the devices. As an example of such kind of the communication system, Patent Literature 1 discloses a transmission and reception system which communicates only with near-by slaves among a plurality of slaves located in the periphery of a master in a transmission and reception system using the short range wireless communication including Bluetooth (a registered trademark). Further, Patent Literature 2 discloses a transmission and reception system which prevents a wrong connection and can assuredly communicate with a desired communication party in a short range communication system by a cash register device and a communication terminal including a Bluetooth (the registered trademark) portable terminal that mutually use the short range wireless communication.

In the proximity wireless communication and the short range wireless communication, a high speed transmission is investigated in order to transmit much information in a short time. For instance, in an IEEE 802.11n standard of the wireless LAN, a microwave band including 2.4 GHz and 5 GHz is used and an MIMO (Multiple Input Multiple Output) and a channel bonding are applied, so that a transmission rate is increased to about several hundred Mbps to achieve a high speed transmission.

Further, for the proximity wireless communication including TransferJet (a registered trademark), the proximity wireless communication is investigated in which a microwave band of 4.5 GHz is used and the transmission rate is increased as high as several hundred Mbps or so. Patent Literature 3 discloses a wireless communication device which controls a wireless communication in accordance with a detected result of a magnetic field so that a consumed power may be suppressed in the wireless communication device including a first wireless communication section using a proximity wireless communication meeting a large capacity transmission including the TransferJet (the registered trademark) and a second wireless communication section using the proximity wireless communication including the NFC through the magnetic field.

CITATION LIST

Patent Literature

Patent Literature 1: JP-A-2003-78478
Patent Literature 2: JP-A-2004-247794
Patent Literature 3: JP-A-2010-199752

SUMMARY OF INVENTION

Technical Problem

In the proximity wireless communication, when a communication can be performed in a range exceeding the short distance (the several cm or so), there is a fear that a wrong communication with some other devices than the near-by devices may possibly arise. For instance, when the wicket of the railway station is supposed to be present, an inconvenience arises that an own device communicates with not the wicket that has a reader/writer to which the own device is allowed to come close, but with a reader/writer of a neighboring wicket.

Thus, usually, a transmission power of a beacon transmitted to a slave device from a master device and a transmission power of data transmitted and received between devices are decreased to reduce a range of a radio wave so that a communication distance is limited within a short range. However, when the range of the radio wave is physically limited to limit a communicable area, a problem arises that robustness is deteriorated and there is a fear that a reliability of communication may be possibly deteriorated. Especially, in order to perform a wireless communication system in which the proximity wireless communication is achieved at a higher speed and the transmission rate is increased as high as several Gbps or so, it is an important problem to prevent a wrong communication and ensure a reliability of communication.

The present invention is devised by considering the above-described circumstances and it is an object of the present invention to properly limit a communicable area in a proximity wireless communication and prevent a wrong communication.

Solution to Problem

A wireless communication terminal according to the present invention includes: a beacon receiver which receives a first beacon signal transmitted from a communication party device by a proximity wireless communication, the first beacon signal including information related to a communicable area of the proximity wireless communication; a communicable area deciding section which estimates a distance to the communication party device by using the first beacon signal to decide a position of an own device; and a connection controller which uses a decided result of the communicable area deciding section, and does not connect the own device to the communication party device using the proximity wireless communication when the beacon receiver can receive the first beacon signal, but it is decided that the position of the own device is located outside the communicable area of the proximity wireless communication, and connects the own device to the communication party device using the proximity wireless communication when the beacon receiver can receive the first beacon signal and it is decided that the position of the own device is located inside the communicable area of the proximity wireless communication.

A wireless communication device according to the present invention includes: a beacon generator which generates a first beacon signal including information related to a communicable area of a proximity wireless communication; a beacon transmitter which transmits the first beacon signal in a first cycle by using a transmission power which allows the first beacon signal to reach beyond the communicable area; a signal receiver which receives a proximity wireless communication connection request signal for requesting for a connection of the proximity wireless communication from a communication party terminal which has received the first beacon signal; and a connection controller which uses the proximity wireless communication connection request signal, and does not connect the communication party terminal using the proximity wireless communication to the wireless communication device when the communication party terminal can receive the first beacon signal, but a position of the communication party terminal is located outside the communicable area of the proximity wireless communication, and connects the communication party terminal to the wireless communication device when the communication party terminal can receive the first beacon signal and the position of the communication party terminal is located inside the communicable area of the proximity wireless communication.

A wireless communication method according to the present invention is a wireless communication method in a wireless communication terminal capable of performing a proximity wireless communication, the wireless communication method including: a step of receiving a first beacon signal transmitted from a communication party device by the proximity wireless communication, the first beacon signal including information related to a communicable area of the proximity wireless communication; a step of estimating a distance to the communication party device by using the first beacon signal to decide a position of an own device; and a step of using a decided result of the position of the own device, not connecting the own device to the communication party device using the proximity wireless communication when the own device can receive the first beacon signal, but it is decided that the position of the own device is located outside the communicable area of the proximity wireless communication, and connecting the own device to the communication party device by using the proximity wireless communication when the own device can receive the first beacon signal and it is decided that the position of the own device is located inside the communicable area of the proximity wireless communication.

A wireless communication method according to the present invention is a wireless communication method in a wireless communication device capable of performing a proximity wireless communication, the wireless communication method including: a step of generating a first beacon signal including information related to a communicable area of the proximity wireless communication; a step of transmitting the first beacon signal in a first cycle by using a transmission power which allows the first beacon signal to reach beyond the communicable area; a step of receiving a proximity wireless communication connection request signal for requesting for a connection of the proximity wireless communication from a communication party terminal which has received the beacon signal; and a step of using the proximity wireless communication connection request signal, and not connecting the communication party terminal using the proximity wireless communication to the wireless communication device when the communication party terminal can receive the first beacon signal, but a position of the communication party terminal is located outside the communicable area of the proximity wireless communication, and connecting the communication party terminal to the wireless communication device by using the proximity wireless communication when the communication party terminal can receive the first beacon signal and the position of the communication party terminal is located inside the proximity wireless communication.

Advantageous Effects of Invention

According to the present invention, a communicable area in a proximity wireless communication can be properly limited and a wrong communication can be prevented.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a diagram showing a schematic arrangement and structure of a wireless communication system according to a first embodiment of the present invention.

FIG. **2** is a block diagram showing a functional structure of a master device of the present embodiment.

FIG. **3** is a block diagram showing a functional structure of a slave device of the present embodiment.

FIG. **4** is an explanatory view of an operation showing operations at the time of starting and finishing a proximity wireless communication in the first embodiment.

FIG. **5** is a sequence diagram showing processes of the master device and the slave device at the time of starting and finishing the proximity wireless communication in the first embodiment.

FIG. **6** is a diagram showing an example of a format of a beacon signal used in the wireless communication system of the present embodiment.

FIG. **7** is a flowchart showing a procedure of a process for deciding whether the slave device is located inside or outside an area of the proximity wireless communication in the slave device of the present embodiment.

FIG. **8** is a diagram showing a schematic arrangement and structure of a wireless communication system according to a second embodiment.

FIG. **9** is an explanatory view of an operation showing operations at the time of starting and finishing a proximity wireless communication in the second embodiment.

FIG. **10** is a sequence diagram showing processes of a master device and a slave device until the start of the proximity wireless communication in the second embodiment.

FIG. **11** is a diagram showing a first applied example of the wireless communication system of the present embodiment.

FIG. **12** is a diagram showing a second applied example of the wireless communication system of the present embodiment.

FIG. **13** is a diagram showing a third applied example of the wireless communication system of the present embodiment.

MODES FOR PERFORMING INVENTION

In present embodiments, a wireless communication terminal, a wireless communication device and a wireless communication method are exemplified which are used in a wireless communication system that can perform a proximity wireless communication in a short distance such as several cm or so. Especially, in the present embodiments, a wireless communication device and a wireless communication terminal are further supposed which can achieve a short range wireless communication in a short range such as several ten cm to several m or so as well as the proximity wireless communication, and one examples of structures and operations are shown.

Here, as the proximity wireless communication, a ultra high speed wireless communication system is investigated which has a transmission rate of several Gbps or so exceeding a transmission rate of several hundred Mbps of the TransferJet (the registered trademark) to obtain a higher speed. For instance, in WiGig (a registered trademark) in which a scheme of a specification is developed by WiGig Alliance (Wireless Gigabit Alliance), a transmission rate of 6 Gbps is aimed at by using a milliwave band of 60 GHz.

In the ultra high speed wireless communication system using a frequency band of the milliwave band, when the proximity wireless communication is used, it is important to prevent a wrong communication and ensure a reliability of communication. In the present embodiment, a communicable area in the proximity wireless communication can be properly limited and a wrong communication can be prevented.

First Embodiment

A first embodiment shows a limiting method of the communicable area in the proximity wireless communication and examples of the wireless communication terminal and the wireless communication device using the proximity wireless communication.

In the first embodiment, in order to limit systematically the communicable area, a distance between the devices using the proximity wireless communication is estimated by using signal strength of a reception signal to perform a communication and connection in a proximity wireless communication area (the communicable area). As the wireless communication system, a wireless communication system is supposed to perform a communication by the proximity wireless communication between a master device (a wireless communication device A) as the wireless communication device and a slave device (a wireless communication device B) as the wireless communication terminal. In the present embodiment, in order to discriminate the slave device from the master device, the slave device is explained as the wireless communication terminal and the master device is explained as the wireless communication device.

FIG. **1** is a diagram showing a schematic arrangement and structure of the wireless communication system according to the first embodiment. The master device **10** transmits a beacon signal for performing a communication by the proximity wireless communication to a peripheral space. A transmission power of the beacon signal is set so that the beacon signal may reach beyond the proximity wireless communication area **30**, and a beacon may be received even outside the proximity wireless communication area.

The slave device **20** which receives the beacon signal from the master device **10** estimates the distance from the master device **10** by using a received signal strength of the beacon signal (or an attenuation quantity of the transmission power). Then, the slave device **20** decides whether or not the distance from the master device **10** is located within the proximity wireless communication area. When the distance from the master device is located within the proximity wireless communication area, the slave device is connected to the master device **10** to transmit and receive data by the proximity wireless communication.

Namely, when the slave device moves from an outside of an area (**20**A) of the proximity wireless communication area **30** to enter an inside of the area (**20**B) as in the slave devices **20**A and **20**B, the slave device is connected to the master device **10** to transmit and receive the data.

On the other hand, a slave device **40** having a long distance hardly receives the beacon signal from the master device **10** or does not communicate with the master device **10** because a distance estimated result indicates an outside of the proximity wireless communication area.

<Structure of Device>

FIG. **2** is a block diagram showing a functional structure of the master device **10** according to the present embodiment.

The master device **10** includes an antenna **101**, a milliwave radio frequency section **102**, a frame transmitter **103**, a milliwave modulator **104**, a milliwave demodulator **105**, a frame receiver **106**, a memory **107**, a transmission power controller **108**, a timer **109** and a processing section **110**.

The milliwave radio frequency section **102** is a front end for a wireless communication of, for instance, a milliwave band of 60 GHz to transmit and receive a radio signal of the milliwave band through the antenna **101**. The memory **107** is a storing section for storing transmission data and reception data.

The frame transmitter **103** generates a frame of a transmission signal in accordance with the transmission data outputted from the memory **107**. For instance, a transmission frame based on an IEEE 802.11ad is generated.

The milliwave modulator **104** modulates the transmission frame generated in the frame transmitter **103** to perform a modulating process based on, for instance, the IEEE 802.11ad and outputs the modulated transmission signal to the milliwave radio frequency section **102**.

The milliwave radio frequency section **102** converts a frequency of the transmission signal, amplifies an electric power and transmits the transmission signal as the radio signal of the milliwave band through the antenna **101**. Further, the milliwave radio frequency section **102** receives the radio signal of the milliwave band through the antenna **101**, amplifies the signal, converts a frequency and outputs the reception signal to the milliwave demodulator **105**.

The milliwave demodulator **105** demodulates the reception signal received in the milliwave radio frequency section **102** to perform a demodulating process based on, for instance, the IEEE 802.11ad and outputs a demodulated reception frame to the frame receiver **106**.

The frame receiver **106** analyzes a frame of the reception signal to analyze a reception frame based on, for instance IEEE 802.11ad and inputs and stores reception data of an analyzed result to the memory **107**.

The transmission power controller **108** controls a transmission power of the beacon signal for the proximity wireless communication or the short range wireless communication and other transmission signal in accordance with an instruction from the processing section **110**.

The processing section **110** includes a microcomputer having a processor and a memory. The processing section **110** executes a predetermined program stored in the memory to process operations respectively in the master device **10**. The timer **109** counts a predetermined time and outputs time information for determining a transmission timing of a beacon signal to the processing section **110**.

The processing section **110** includes a beacon generator **113**, a communicable area deciding section **111** and a connection controller **112**. The beacon generator **113** generates a beacon signal for the proximity wireless communication including information related to the communicable area of the proximity wireless communication. Further, when the short range wireless communication is performed, the beacon generator generates a beacon signal for the short range wireless communication including information related to the short range wireless communication. In this case, the processing section **110** outputs the beacon signal in a predetermined cycle so as to correspond to the transmission timing of the beacon signal supplied from the timer **109**.

The communicable area deciding section **111** estimates a distance from a communication party terminal and decides whether or not the communication party terminal is located within the communicable area of the proximity wireless communication to output position information of the communication party terminal. The distance to the communication party terminal can be estimated by a method for measuring a reception power (the received signal strength) by the use of the reception signal received in the milliwave radio frequency section **102** and comparing the reception power with a transmission power of the communication party terminal.

When the connection controller **112** receives a connection request signal for the proximity wireless communication for requesting for a connection to the proximity wireless connection from the communication party terminal which receives the beacon signal, the connection controller connects the communication party terminal by using the proximity wireless communication. In this case, even when the communication party terminal can receive the beacon signal, if a position of the communication party terminal is located outside the communicable area of the proximity wireless communication, the connection controller **112** does not connect the communication party terminal using the proximity wireless communication. On the other hand, when the communication party terminal can receive the beacon signal and the position of the communication party terminal is located within the communicable area of the proximity wireless communication, the connection controller **112** connects the communication party terminal by using the proximity wireless communication.

In the above-described structure, the timer **109**, the processing section **110**, the memory **107**, the frame transmitter **103**, the milliwave modulator **104**, the milliwave radio frequency section **102** and the antenna **101** realize a function of a beacon transmitter. Further, the antenna **101**, the milliwave radio frequency section **102**, the milliwave demodulator **105**, the frame receiver **106**, the memory **107** and the processing section **110** realize a function of a signal receiver.

FIG. **3** is a block diagram showing a functional structure of the slave device **20** according to the present embodiment.

The slave device **20** includes an antenna **201**, a milliwave radio frequency section **202**, a frame transmitter **203**, a milliwave modulator **204**, a milliwave demodulator **205**, a frame receiver **206**, a memory **207**, a reception power measuring section **208**, a timer **209** and a processing section **210**.

The milliwave radio frequency section **202** is a front end for a wireless communication of, for instance, a milliwave band of 60 GHz to transmit and receive a radio signal of the milliwave band through the antenna **201**. The memory **207** is a storing section for storing transmission data and reception data.

The frame transmitter **203** generates a frame of a transmission signal in accordance with the transmission data outputted from the memory **207**. For instance, a transmission frame based on the IEEE 802.11ad is generated.

The milliwave modulator **204** modulates the transmission frame generated in the frame transmitter **203** to perform a modulating process based on, for instance, the IEEE 802.11ad and outputs the modulated transmission signal to the milliwave radio frequency section **202**.

The milliwave radio frequency section **202** converts a frequency of the transmission signal, amplifies an electric power and transmits the transmission signal as the radio signal of the milliwave band through the antenna **201**. Further, the milliwave radio frequency section **202** receives the radio signal of the milliwave band through the antenna **201**, amplifies the signal, converts a frequency and outputs the reception signal to the milliwave demodulator **205**.

The milliwave demodulator **205** demodulates the reception signal received in the milliwave radio frequency section **202** to perform a demodulating process based on, for instance, the IEEE 802.11ad and outputs a demodulated reception frame to the frame receiver **206**.

The frame receiver **206** analyzes a frame of the reception signal to analyze the reception frame based on, for instance, IEEE 802.11ad and inputs and stores reception data of an analyzed result to the memory **207**.

The reception power measuring section **208** measures a reception power of the beacon signal for the proximity wireless communication received in the milliwave radio frequency section **202** and outputs a measured result to the processing section **210**.

The processing section **210** includes a microcomputer having a processor and a memory. The processing section **210** executes a predetermined program stored in the memory to process operations respectively in the slave device **20**. The timer **209** counts a predetermined time and outputs time information for determining a reception timing of the beacon signal to the processing section **210**.

The processing section **210** includes a communicable area deciding section **211** and a connection controller **212**. The communicable area deciding section **211** estimates a distance from a communication party device and decides whether or not a position of an own device is located within the communicable area of the proximity wireless communication. The distance to the communication party device can be estimated by a method for measuring a reception power (the received signal strength) by the use of the beacon signal received in the milliwave radio frequency section **202** and comparing the reception power with a transmission power of the communication party device.

When the connection controller **212** connects the own device to the communication party device by using the proximity wireless communication in accordance with a decided result as to whether the own device is located inside or outside the communicable area of the proximity wireless communication. In this case, even when the own device can receive the beacon signal for the proximity wireless communication, if the position of the own device is located outside the communicable area of the proximity wireless communication, the connection controller **212** does not connect the own device to the communication party device by using the proximity wireless communication. On the other hand, when the own device can receive the beacon signal for the proximity wireless communication and the position of the own device is located within the communicable area of the proximity wireless communication, the connection controller **112** connects the own device to the communication party device by using the proximity wireless communication. Here, the communicable area of the proximity wireless communication is an area narrower than an area where the beacon signal for the proximity wireless communication can be received

In the above-described structure, the antenna **201**, the milliwave radio frequency section **202**, the milliwave demodulator **205**, the frame receiver **206**, the memory **207** and the processing section **210** realize a function of a beacon signal receiver.

<Operation of Wireless Communication System>

Now, operations of the master device **10** and the slave device **20** in the wireless communication system according to the first embodiment will be described below. FIG. **4** is an explanatory view of an operation showing operations at the time of starting and finishing the proximity wireless communication in the first embodiment. In FIG. **4**, a horizontal axis indicates a time and shows a signal transmitted and received between the master device **10** and the slave device **20**. Here, a communication signal including the beacon signal transmitted and received between the devices is supposed to be transmitted as a packet. Further, FIG. **5** is a sequence diagram showing processes of the master device **10** and the slave device **20** at the time of starting and finishing the proximity wireless communication in the first embodiment.

The master device **10** (the wireless communication device A) periodically transmits the beacon signal **51** for communication by using the proximity wireless communication (S**11**). The master device **10** transmits the beacon signal **51** at predetermined short cycles (for instance, 1 ms).

Namely, a beacon transmitting process S**11** in FIG. **5** is periodically performed. Proximity wireless communication information included in the beacon signal **51** includes at least one or more of identifying information for the proximity wireless communication, transmission power information and communicable area definition information (about several cm). The transmission power information and the communicable area definition information among them are used as information related to the communicable area of the proximity wireless communication. As the communicable area definition information, for instance, dimension information that defines the dimension of the proximity wireless communication area and communication distance upper limit information of the proximity wireless communication or the like may be used. As the communication distance upper limit information of the proximity wireless communication, for instance, a maximum attenuation quantity of the transmission power in the proximity wireless communication area may be employed.

A transmission power of the beacon signal **51** is set substantially to a level in which a range of the beacon signal **51** exceeds the proximity wireless communication area. For instance, the transmission power is set to a relatively small value by considering a consumed power.

As the communicable area definition information (about several cm) of the proximity wireless communication and the transmission power information, values previously set in the wireless communication system may be used. When the previously set values are used, information can be omitted in the beacon signal **51**.

When the slave device **20** (the wireless communication device B) receives the beacon signal **51** (S**21**), the slave device **20** analyzes the proximity wireless communication information included in the beacon signal **51** to measure the received strength of the beacon signal **51**. Then, the slave device **20** estimates the distance from the master device **10** as a transmitter of the beacon signal **51** by using the proximity wireless communication information and information of the received signal strength of the beacon signal **51** to decide whether the slave device is located inside or outside the proximity wireless communication area (S**22**).

When the slave device **20** decides that the slave device **20** is located inside the proximity wireless communication area in a process for deciding whether the slave device **20** is located inside or outside the proximity wireless communication area (S**23**), the slave device **20** transmits a communication connection request signal **52** to the master device **10** (S**24**). As connection request information included in the communication connection request signal **52**, the identifying information for the proximity wireless communication, the transmission power information or the like is used.

When the master device **10** receives the communication connection request signal **52** from the slave device **20** (S**12**), the master device **10** analyzes the connection request information included in the communication connection request signal **52** to measure the received strength of the communication connection request signal **52**. Then, the master device **10** estimates the distance to the slave device **20** as a transmitter of the communication connection request signal **52** by using the connection request information and information of the received signal strength of the communication connection request signal **52** to decide whether or not the slave device is located inside or outside the proximity wireless communication area.

When the master device **10** decides that the slave device **20** is located within the proximity wireless communication area, the master device **10** transmits a communication connection permission signal **53** to the slave device (S**13**). When the master device **10** estimates the distance to the slave device **20** and the slave device **20** is located within the proximity wireless communication area, the master device **10** may transmit the communication connection permission signal **53**, or the master device **10** may omit a deciding process in the proximity wireless communication area to transmit the communication connection permission signal **53** to the slave device **20**.

When the slave device **20** receives the communication connection permission signal **53** from the master device **10** (S**25**), the proximity wireless communication is connected between the master device **10** and the slave device. Then, after a next beacon signal **51** is transmitted, the proximity wireless communication is started and a data signal **54** is transmitted and received between the master device **10** and the slave device **20** (S**14**, S**26**). In FIG. **4**, the data signal **54** is shown which is transmitted from the master device **10** to the slave device **20**.

After that, when the slave device **20** decides that the slave device **20** is located outside the proximity wireless communication area in the process for deciding whether the slave device is located inside or outside the proximity wireless communication area (S**27**), the slave device transmits a communication disconnection request signal **55** to the master device **10**. When the master device **10** receives the communication disconnection request signal **55** from the slave device **20** (S**15**), the master device **10** transmits a communication disconnection permission signal **56** to the slave device **20** (S**16**). When the slave device **20** receives the communication disconnection permission signal **56** from the master device **10** (S**29**), the proximity wireless communication is disconnected between the master device **10** and the slave device.

<Beacon Format>

One example of the beacon signal **51** is shown. FIG. **6** is a diagram showing an example of a format of the beacon signal used in the wireless communication system according to the present embodiment. An illustrated example shows an example using a beacon frame format based on an IEEE 802.11ad Draft 1.0.

As shown in FIG. **6**(A), the beacon signal **51** includes FC (Frame Control) **301**, Duration **302**, RA **303**, Body **304** and FCS (Frame Check Sequence) **305**. The FC **301** indicates frame type information and is 0x03 in the case of a frame of a beacon for a milliwave communication. The Duration **302** indicates information showing a remaining time until a beacon transmission period is finished. The Body **303** indicates a main body of beacon information, which will be described below. The RA **304** indicates BSSID of a master station (the master device). The FCS **305** indicates a bit string for inspecting an error of the frame.

As shown in FIG. **6**(B), the Body of the beacon signal **51** includes Timestamp **311**, Sector Sweep **312**, Beacon Interval **313**, Beacon Interval Control **314** and mmWave Parameters **315** in the first section. They are information based on the IEEE 802.11ad. The Body of the beacon signal **51** includes a predetermined number of Information Elements (IE). In this example, as the Information Elements, SSID element **316** and proximity wireless communication information element **317** are included.

The SSID element **316** is the IE showing SSID (Service Set Identifier) as identifying information for designating a specific network and predetermined by a wireless LAN standard of IEEE 802.11 series. As shown in FIG. **6**(C), the SSID element **316** includes Element ID **321**, Length **322** and SSID **323**.

The proximity wireless communication information element **317** is the IE showing the beacon signal for the proximity wireless communication and includes information related to the communicable area of the proximity wireless communication. As shown in FIG. **6**(D), the proximity wireless communication information element **317** includes Element ID **331**, Length **332**, identifying information **333**, transmission power information **334** and maximum attenuation quantity information **335**. In this example, the Element ID is set to 172 and Length is set to 5. The identifying information **333** is set to "1" for the proximity wireless communication and to "0" for the short range wireless communication.

The transmission power information **334** indicates information of one byte that the transmission power of the beacon signal is expressed by 0 to 255 dB. The maximum attenuation quantity information **335** corresponds to the communication distance upper limit information of the proximity wireless communication as one example of the communicable area definition information and is information showing the maximum attenuation quantity of the transmission power in the proximity wireless communication area. The maximum attenuation quantity information **335** indicates information of one byte that the maximum attenuation quantity up to a communication distance upper limit of the proximity wireless communication is expressed by 0 to 255 dB.

Further, as the IE showing the beacon signal for the proximity wireless communication, Vender Specific information element **318** may be used in place of the proximity wireless communication information element **317**. The Vender Specific information element **318** is the IE which can be independently used by venders of the wireless communication terminal and the device. As shown in FIG. **6**(E), the Vender Specific information element **318** includes Element ID **341**, Length **342**, OUI (Organizationally Unique Identifier) **343**, identifying information **344**, transmission power information **345** and maximum attenuation quantity information **346**. In this example, the Element ID is set to 221 and the Length is set to 8.

The OUI **343** indicates the first half 24 bit part of a MAC address used in a LAN and identifying information assigned respectively to the venders of the wireless communication terminal and the device. As the identifying information **344**, the transmission power information **345** and the maximum attenuation quantity information **346**, the same information as that of the above-described proximity wireless communication information element **317** can be used.

<Process for Deciding Whether Slave Device is Located Inside or Outside Proximity Wireless Communication Area>

Shown is one example of a procedure of a process for deciding whether the slave device is located inside or outside the proximity wireless communication area. FIG. **7** is a flowchart showing the procedure of the process for deciding whether the slave device is located inside or outside the proximity wireless communication area in the slave device **20** of the present embodiment. The procedures respectively described below are mainly performed in the processing section **210** of the slave device **20**. FIG. **7** shows an operation when the beacon signal shown in FIG. **6** is received.

When the slave device **20** receives the radio signal, the slave device **20** decides whether or not the reception frame is the beacon signal for the milliwave communication in the processing section **210** (S**101**). In this case, the processing section **210** refers to the FC **301** of the reception frame, and when the FC is equal to 0x03, the processing section decides that the reception frame is the beacon signal for the milliwave communication. When the reception frame is not the beacon signal for the milliwave communication (S**101** No), the processing section **210** decides that the slave device is located outside the proximity wireless communication area (S**108**) to finish the process.

When the reception frame is the beacon signal for the milliwave communication (S**101** Yes), then, the processing section **210** analyzes the information (the beacon information) included in the beacon signal (S**102**). As an analysis of the beacon information, a frame analyzing process based on the IEEE 802.11ad is performed. Specifically, the Duration **302**, the RA **302** and the Timestamp **311**, the Sector Sweep **312**, the Beacon Interval **313**, the Beacon Interval Control **314** and the mmWave Parameters **315** of the Body **304** are analyzed.

Subsequently, the processing section **210** refers to the element ID of the IE to decide whether or not the element ID is the element ID of the proximity wireless communication information element **317** (S**103**). When the IE is the proximity wireless communication information element **317**, the processing section **210** advances to a next process. When the IE is not the proximity wireless communication information element **317**, the processing section decides that the slave device is located outside the proximity wireless communication area (S**108**) to finish the process.

Subsequently, the processing section **210** refers to the identifying information **333** in the proximity wireless communication information element **317** to decide whether or not the identifying information **333** is set for the proximity wireless communication (=1) (S**104**). When the identifying information **333** is set for the proximity wireless communication, the processing section **210** advances to a next process. When the identifying information **333** is not set for the proximity wireless communication, the processing section decides that the slave device is located outside the proximity wireless communication area (**108**) to finish the process.

Then, the processing section **210** performs a calculation for deciding whether or not the slave device is located inside or outside the proximity wireless communication area by using the transmission power information **334**, the maximum attenuation quantity information **335** and the information of the received signal strength of the received beacon signal (S**105**). When the processing section **210** subtracts the received signal strength from the transmission power of the beacon signal and compares an obtained result with the maximum attenuation quantity to obtain a relation expressed by (the transmission power)−(the received signal strength)<(the maximum attenuation quantity), the processing section **210** advances to a next process. Otherwise, the processing section **210** decides that the slave device is located outside the proximity wireless communication area (S**108**) to finish the process.

Then, the processing section **210** performs an error inspecting process by using the FCS **305** to decide whether or not an error inspected result is normal (S**106**). When the error inspected result is normal, the processing section **210** decides that the slave device is located inside the proximity wireless communication area (S**107**) to finish the process. When the error inspected result is abnormal, the processing section **210** decides that the slave device is located outside the proximity wireless communication area (S**108**) to finish the process.

According to the present embodiment, the communicable area can be limited by using a decision of a distance as well as a physical range of a radio wave. Even in the physical range of the radio wave, that is located outside the communicable area, a connection is not performed, so that a wrong transmission can be prevented at the time of the proximity wireless communication. Especially, when the present invention is applied to the ultra high speed wireless communication system, the wireless communication terminal and the wireless communication device which use the milliwave band, a high transmission rate and a high reliability can be compatible and a larger effect can be obtained.

Second Embodiment

A second embodiment shows a method for connecting and disconnecting a communication of a proximity wireless communication and one example of a wireless communication terminal and a wireless communication device using the proximity wireless communication.

In the second embodiment, in order to efficiently connect and disconnect the proximity wireless communication, the wireless communication terminal and the wireless communication device initially connect a communication by a short range wireless communication in a short range wireless communication area (several ten cm to several m or so), and when the wireless communication terminal and the wireless communication device come near to a proximity wireless communication area (several cm or so), they are connected by a proximity wireless communication.

Namely, the wireless communication terminal and the wireless communication device decide whether or not a communication party station is located in the proximity of the proximity wireless communication area by using a signal strength of a received signal by the short distance wireless communication. When the wireless communication terminal and the wireless communication device decide that the communication party station is located in the vicinity of the proximity wireless communication area, the wireless communication terminal and the wireless communication device start a communication connecting operation of the proximity wireless communication and are connected by the proximity wireless communication in the proximity wireless communication area (a communicable area).

As a wireless communication system, a wireless communication system is supposed, like the first embodiment, to perform a communication by the proximity wireless communication between a master device (a wireless communication device A) and a slave device (a wireless communication device B). Here, different points from those of the first embodiment will be mainly described.

FIG. **8** is a diagram showing a schematic arrangement and structure of the wireless communication system according to the second embodiment. The master device **10** initially transmits a beacon signal for performing a communication by the short range wireless communication to a peripheral space. A transmission power of the beacon signal is increased so that the beacon signal may reach the short range wireless communication area (the several ten cm to the several m or so) and the beacon signal is transmitted in a long transmission cycle.

The slave device **20** which receives the beacon signal for the short range wireless communication from the master device **10** starts a communication connection to the master device **10** by the short range wireless communication to transmit and receive data. Then, the slave device **20** estimates a distance from the master device **10** by using a received signal strength of the beacon signal for the short range wireless communication, a received signal strength of a data signal or an attenuation quantity of the transmission power.

When the slave device **20** estimates that the distance from the master device is located in the proximity of the proximity wireless communication area, the slave device **20** transmits communication area proximity information to the master device **10**. When the master device **10** receives the communication area proximity information from the slave device **20**, the master device switches the beacon signal to a beacon signal for the proximity wireless communication and transmits the beacon signal to the peripheral space. A transmission power of the beacon signal is decreased so that a range may exceed the proximity wireless communication area (up to a neighbor) and the beacon signal is transmitted in a short transmission cycle.

The slave device **20** which receives the beacon signal for the proximity wireless communication decides whether the slave device **20** is located inside or outside the proximity wireless communication area as in the first embodiment. When the slave device **20** decides that the slave device **20** is located inside the proximity wireless communication area, the slave device **20** is connected to the master device **10** to transmit and receive data by the proximity wireless communication.

Namely, the master device **10** transmits the beacon signal for the short range wireless communication and the slave device is connected to communicate with the master device **10** initially by the short range wireless communication outside the area (**20**C) of the proximity wireless communication area **30** like the slave devices **20**C, **20**D and **20**E. Then, when the slave device moves to come to the proximity (**20**D) of the proximity wireless communication area **30**, the master device **10** switches the beacon signal to the beacon signal for the proximity wireless communication. When the slave device enters inside the area (**20**E) from the proximity of the area, the slave device starts to a communication connection to the master device **10**.

<Operation of Wireless Communication System>

Now, operations of the master device **10** and the slave device **20** in the wireless communication system of the second embodiment will be described below. FIG. **9** is an explanatory view of an operation showing operations at the time of starting and finishing the proximity wireless communication in the second embodiment. In FIG. **9**, a horizontal axis indicates a time and shows a signal transmitted and received between the master device **10** and the slave device **20**. Here, a communication signal including the beacon signal transmitted and received between the devices is supposed to be transmitted as a packet. Further, FIG. **10** is a sequence diagram showing processes of the master device **10** and the slave device **20** until the proximity wireless communication is started in the second embodiment.

The master device **10** (the wireless communication device A) periodically transmits the beacon signal **61** used for a communication by the short range wireless communication (S**31**). The master device **10** generates the beacon signal **61** for the short range wireless communication including short range and proximity wireless communication information related to the short range wireless communication and the proximity wireless communication. The master device **10** transmits the beacon signal **61** at predetermined cycles (for instance, 100 ms) longer than the beacon signal for the proximity wireless communication.

Namely, a beacon transmitting process S**31** for the short range wireless communication in FIG. **10** is periodically performed. The short range and proximity wireless communication information included in the beacon signal **61** includes at least one or more of identifying information for the short range wireless communication, transmission power information and communicable area definition information (about several ten cm to several m) related to the short range wireless communication. As the communicable area definition information, for instance, dimension information that defines the dimension of the short range wireless communication area and communication distance upper limit information of the short range wireless communication or the like may be used. As the communication distance upper limit information of the short range wireless communication, for instance, a maximum attenuation quantity of the transmission power in the short range wireless communication area may be employed.

The transmission power of the beacon signal **61** is set to a relatively large value so that the range of the beacon signal **61** may cover an inside of the short range wireless communication area (about several ten cm to several m).

When the slave device **20** (the wireless communication device B) receives the beacon signal **61** (S**51**), the slave device **20** transmits a communication connection request signal **62** as a connection request for the short range wireless communication to the master device **10** (S**52**). When the master device **10** receives the communication connection request signal **62** from the slave device **20** (S**32**), the master device **10** transmits a communication connection permission signal **63** as a connection permission of the short range wireless communication to the slave device **20** (S**33**).

When the slave device **20** receives the communication connection permission signal **63** from the master device **10** (S**53**), the short range wireless communication is connected between the master device **10** and the slave device. Then, after a next beacon signal **61** is transmitted, the short range wireless communication is started and a data signal is transmitted and received between the master device **10** and the slave device **20** (S**34**, S**54**). As a procedure of a communication connection to the short range wireless communication, the same connection sequence as that of a known wireless LAN may be used.

Then, the slave device **20** estimates a distance from the master device **10** as a communication party by the received signal strength of the beacon signal **61** for the short range wireless communication or the received signal strength of the data signal transmitted and received by using the short range wireless communication to decide whether or not the slave device is located in the vicinity of the proximity wireless communication area (S**55**). A process for deciding whether or not the slave device is located in the proximity of the proximity wireless communication area can be performed by the same procedure as that of the process for deciding whether the slave device is located inside or outside the proximity wireless communication area in the first embodiment.

When the slave device **20** decides that the slave device is located in the vicinity of the proximity wireless communication area in the process for deciding whether or not the slave device is located in the vicinity of the proximity wireless communication area (S**56**), the slave device **20** transmits a communication area proximity information signal **64** to the master device **10** (S**57**). When the master device **10** receives the communication area proximity information signal **64** from the slave device **20** (S**35**), the master device **10** periodically transmits the beacon signal **51** for performing a communication by the proximity wireless communication (S**36**). The master device **10** switches appended information, the transmission power and a transmission cycle of the beacon signal for the short range wireless communication to those for the proximity wireless communication.

The master device **10** generates the beacon signal **51** for the proximity wireless communication including the proximity wireless communication information related to the proximity wireless communication like the first embodiment. The master device **10** periodically transmits the beacon signal **51** at predetermined short cycles (for instance, 1 ms). Namely, the transmitting process S**36** of the beacon for the proximity wireless communication in FIG. **10** is periodically performed.

Proximity wireless communication information included in the beacon signal **51** includes at least one or more of identifying information for the proximity wireless communication, transmission power information and communicable area definition information (about several cm). A transmission power of the beacon signal **51** is set substantially to a level in which a range of the beacon signal **51** exceeds the proximity wireless communication area (about several cm). For instance, the transmission power is set to a value smaller than that for the short range wireless communication by considering a consumed electric power. A below described communication connecting procedure of the proximity wireless communication is the same as that of the first embodiment.

When the slave device **20** receives the beacon signal **51** (S**58**), the slave device **20** estimates a distance from the master device **10** by using the proximity wireless communication information and information of the received signal strength of the beacon signal **51** to decide whether the slave device is located inside or outside the proximity wireless communication area (S**59**). A process for deciding whether the slave device is located in side or outside the proximity wireless communication area can be performed by the same procedure as that of the first embodiment.

When the slave device **20** decides that the slave device **20** is located inside the proximity wireless communication area in the process for deciding whether the slave device is located inside or outside the proximity wireless communication area (S**60**), the slave device **20** transmits a communication connection request signal **52** as a connection request for the proximity wireless communication to the master device **10** (S**61**).

When the master device **10** receives the communication connection request signal **52** from the slave device **20** (S**37**), the master device **10** transmits a communication connection permission signal **53** as a connection permission of the proximity wireless communication to the slave device (S**38**). When the master device **10** estimates the distance to the slave device **20** and the slave device is located within the proximity wireless communication area, the master device **10** may transmit the communication connection permission signal **53**, or the master device **10** may omit a deciding process in the proximity wireless communication area to transmit the communication connection permission signal **53** to the slave device.

When the slave device **20** receives the communication connection permission signal **53** from the master device **10**

(S**62**), the proximity wireless communication is connected between the master device **10** and the slave device. Then, after a next beacon signal **51** is transmitted, the proximity wireless communication is started and a data signal is transmitted and received between the master device **10** and the slave device **20** (S**39**, S**63**).

After that, when the slave device **20** decides that the slave device is located outside the proximity wireless communication area, the slave device **20** transmits a communication disconnection request signal **55** as a disconnection request for the proximity wireless communication to the master device **10**. When the master device **10** receives the communication disconnection request signal **55** from the slave device **20**, the master device **10** transmits a communication disconnection permission signal **56** as a disconnection permission of the proximity wireless communication to the slave device **20**. When the slave device **20** receives the communication disconnection permission signal **56** from the master device **10**, the proximity wireless communication is disconnected between the master device **10** and the slave device.

After the proximity wireless communication is finished, the master device **10** periodically transmits the beacon signal **61** for the short range wireless communication. The master device **10** switches the appended information, the transmission power and the transmission cycle of the beacon signal for the proximity wireless communication to those for the short range wireless communication. For instance, the identifying information for the proximity wireless communication is switched to the identifying information for the short range wireless communication. The large transmission power is switched to the small transmission power. The transmission cycle 1 ms is switched to the transmission cycle 100 ms.

According to the present embodiment, the communicable area can be limited by using a decision of the distance as well as a physical range of a radio wave. Even in the physical range of the radio wave, that is located outside the communicable area, a connection is not performed, so that a wrong transmission can be prevented at the time of the proximity wireless communication.

When the master device **10** is connected once to the slave device **20** by using the short range wireless communication, and then, the slave device **20** is located in the vicinity of the communicable area of the proximity wireless communication, the master device **10** switches the beacon signal for the short range wireless communication to the beacon signal for the proximity wireless communication and is connected to the slave device **20** by using the proximity wireless communication. Thus, an efficient communication connection and communication disconnection can be performed.

Accordingly, a power for the communication connection can be saved and the communication connection and the communication disconnection can be performed in a short time. Further, even when the proximity wireless communication and the short range wireless communication are used at the same time, a wrong communication can be prevented and a reliability of the communication can be ensured. Especially, when the present invention is applied to the ultra high speed wireless communication system, the wireless communication terminal and the wireless communication device which use a milliwave band, a high transmission rate and a high reliability can be compatible and a larger effect can be obtained.

Applied Example

FIG. **11** is a diagram showing a first applied example of the wireless communication system of the present embodiment. The first applied example shows an example in which the wireless communication system of the present embodiments is applied to a wicket of a railway station or a register of a shop. FIG. **11** shows an example of the wicket.

Master devices **510**A and **510**B are respectively installed in wickets **511**A and **511**B. The master device **510**A performs a proximity wireless communication with a slave device **520** in a proximity wireless communication area while the slave device **520** carried by a user passes the wicket to transmit and receive information related to the wicket. In this case, the master device **510**A performs a certification of the user, a check of ticket information or season ticket information, a settlement process of a charge, a payment process and a distribution of various kinds of information. When the wireless communication system is applied to the register of the shop, the master device performs a certification of a user, a settlement process of a charge, a payment process and a distribution of various kinds of information.

When the wireless communication system of the present embodiment is applied, even if other master device **510**B coexists in a neighboring place, a communicable area can be limited and it can be properly decided whether the slave device is located inside or outside the communicable area. Thus, an erroneous connection to other wireless communication device can be prevented. Further, the proximity wireless communication can be properly connected and disconnected in a short time between the master device **510**A and the slave device **520**.

FIG. **12** is a diagram showing a second applied example of the wireless communication system according to the present embodiments. The second applied example shows an example in which the wireless communication system of the present embodiments is applied to a download system of digital contents.

A content download device **611** is installed in a public area so that a user downloads and obtains desired digital contents. The content download device **611** displays a plurality of digital contents so as to be selected by the user. A plurality of master devices **610**A, **601**B and **610**C are provided correspondingly to kinds of the digital contents. A coordinate relation of the master device and the digital contents is arbitrarily set on a one-to-one basis or a one-to-others basis.

When a slave device **620** held by the user comes close to the master device **610**A, the master device **610**A performs a proximity wireless communication with the slave device **620** in a proximity wireless communication area to transmit and receive information related to the download of the digital contents. In this case, the master device **610**A performs a certification of the user, a download process of the digital contents, a settlement process of a charge, a payment process and a distribution of various kinds of information.

When the wireless communication system of the present embodiments is applied, even if other master devices **610**B and **610**C coexist in neighboring places, a communicable area can be limited and it can be properly decided whether the slave device is located inside or outside the communicable area. Thus, the proximity wireless communication with the master device **610**A to which the user of the slave device **620** is allowed to selectively come close can be normally performed and a reliability of communication can be improved.

FIG. **13** is a diagram showing a third applied example of the wireless communication system according to the present embodiments. The third applied example shows an example in which the wireless communication system of the present embodiments is applied when a communication such as an exchange of files and an exchange of information is performed between wireless communication terminals.

In the above-described embodiments, the wireless communication device is mainly described as the master device and the wireless communication terminal as the slave device. Alternatively, the wireless communication device or the wireless communication terminal may include the master device and the slave device.

In the wireless communication device or the wireless communication terminal, the roles of the master device and slave device may be switched and used depending on a communicating party.

Accordingly, the master device is not limited to a fixed device as shown in FIGS. **11** and **12** and the master device may be a mobile wireless communication device or a wireless communication terminal as shown in FIG. **13**.

A wireless communication terminal **710** and a wireless communication terminal **720** are allowed to come close to each other so that both the wireless communication terminals can perform a proximity wireless communication in a proximity wireless communication area. In this case, one serves as the master device and the other serves as the slave device to perform the proximity wireless communication and a communication on a one-to-one basis such as an exchange of files of digital contents and an exchange of personal information. In the proximity wireless communication, may be performed a communication between a plurality of devices such as a communication on a one-to-others basis.

When the wireless communication system of the present embodiments is applied, even if other wireless communication terminal **730** is present in neighboring place, a communicable area can be limited and it can be properly decided whether the slave device is located inside or outside the communicable area. Thus, a communication and a connection can be normally performed between the wireless communication terminal **710** and the wireless communication terminal **720** which are suitable for the proximity wireless communication and a reliability of communication can be improved.

In the present invention, it is to be understood and included within a scope to be protected that a person with ordinary skill in the art may make various changes and applications in accordance with the description of the specification and the known technique without departing from the gist and scope of the present invention.

Further, component elements in the above-described embodiments may be arbitrarily combined together within a range that does not deviate from the gist of the present invention.

In the above-described embodiment, the structures using hardware are described as the examples. However, the present invention may be realized by software.

Further, the functional blocks used for explaining the embodiments are respectively typically realized by an LSI as an integrated circuit. These functional blocks may be individually formed as one chips respectively or may be formed as one chip so as to include a part or all parts. Here, the functional block is realized as the LSI, however, the functional block may be possibly called an IC, a system LSI, a super LSI and a ultra LSI depending on the difference of degree of integration.

Further, a method for forming the integrated circuit is not limited to the LSI and may be realized by using a special purpose circuit or a general purpose processor. After the LSI is produced, may be used a programmable FPGA (Field Programmable Gate Array) or a reconfigurable processor which can reconfigure a connection and setting of a circuit cell in the LSI.

Further, if an integrated circuit technology appears with which the LSI is replaced in accordance with a progress of a semiconductor technology or another derived technology, the functional blocks may be naturally integrated by using the technique. A biological technology may be possibly adapted.

The present application is based on Japanese Patent Application No. 2011-027720 filed on Feb. 10, 2011, the contents of which are incorporated herein as a reference.

INDUSTRIAL APPLICABILITY

The present invention can effectively limit a communicable area properly in a proximity wireless communication and prevent a wrong communication, and is available as a wireless communication terminal, a wireless communication device and a wireless communication method which can perform a proximity wireless communication using, for instance, a milliwave band.

REFERENCE SIGNS LIST

10: Master device
20, **20**A, **20**B, **20**C, **20**D, **20**E: Slave device
30: Proximity wireless communication area
101: Antenna
102: Milliwave radio frequency section
103: Frame transmitter
104: Milliwave modulator
105: Milliwave demodulator
106: Frame receiver
107: Memory
108: Transmission power controller
109: Timer
110: Processing section
111: Communicable area deciding section
112: Connection controller
113: Beacon generator
201: Antenna
202: Milliwave radio frequency section
203: Frame transmitter
204: Milliwave modulator
205: Milliwave demodulator
206: Frame receiver
207: Memory
208: Reception power measuring section
209: Timer
210: Processing section
211: Communicable area deciding section
212: Connection controller

The invention claimed is:

1. A wireless communication terminal, comprising:

a beacon receiver configured to, in operation, receive a first beacon signal transmitted from a communication party device by a proximity wireless communication, the first beacon signal including information related to a communicable area of the proximity wireless communication;

a communicable area deciding section configured to, in operation decide a position of the wireless communication terminal by using the first beacon signal; and

a connection controller configured to, in operation use a decided result of the communicable area deciding section, and does not connect the wireless communication terminal to the communication party device using the proximity wireless communication when the beacon receiver receives the first beacon signal and the communicable area deciding section decides that the position of the wireless communication terminal is located outside the communicable area of the proximity wireless communication, and connects the wireless communication terminal to the communication party device using the proximity wireless communication when the beacon receiver receives the first beacon signal and the communicable area deciding section decides that the position of the wireless communication terminal is located inside the communicable area of the proximity wireless communication; wherein

the beacon receiver configured to, in operation, further receive a second beacon signal transmitted from the communication party device by a short range wireless communication having a communicable area of the short range wireless communication which is wider than the communicable area of the proximity wireless communication,

the communicable area deciding section configured to, in operation, decide the position of the wireless communication terminal by further using the second beacon signal,

the connection controller configured to, in operation, connect the wireless communication terminal to the communication party device by using the short range wireless communication when the position of the wireless communication terminal is located inside the communicable area of the short range wireless communication and outside the communicable area of the proximity wireless communication in accordance with a decided result of the communicable area deciding section,

the second beacon signal includes identifying information for the short range wireless communication,

the first beacon signal includes identifying information for the proximity wireless communication, and

the first beacon signal has a smaller transmission power and a shorter transmission cycle than those of the second beacon signal.

2. The wireless communication terminal according to claim **1**, wherein

the communicable area of the proximity wireless communication is an area narrower than an area where the first beacon signal can be received.

3. The wireless communication terminal according to claim **1**, wherein

when the beacon receiver receives the first beacon signal and the communicable area deciding section decides that the position of the wireless communication terminal is located within the communicable area of the proximity wireless communication, the connection controller outputs a proximity wireless communication connection request signal to the communication party device.

4. The wireless communication terminal according to claim **1**, wherein

the beacon signal includes transmission power information and communicable area definition information of the beacon signal as the information related to the communicable area, and

the communicable area deciding section configured to, in operation, estimate the distance to the communication party device and decide whether the position of the wireless communication terminal is located inside or outside the communicable area by using received signal strength information of the beacon signal, the transmission power information and the communicable area definition information.

5. The wireless communication terminal according to claim **1**, wherein

when the position of the wireless communication terminal is located in the proximity of an outside of the communicable area in accordance with the decided result of the communicable area proximity deciding section using the second beacon signal, the connection controller informs the communication party device of a transmission request signal for the first beacon signal.

6. A wireless communication device, comprising:

a beacon generator configured to, in operation, generate a first beacon signal including information related to a communicable area of a proximity wireless communication;

a beacon transmitter configured to, in operation, transmit the first beacon signal in a first cycle by using a transmission power which reaches beyond the communicable area;

a signal receiver configured to, in operation, receive a proximity wireless communication connection request signal for requesting a connection of the proximity wireless communication from a communication party terminal which has received the first beacon signal; and

a connection controller configured to, in operation, use the proximity wireless communication connection request signal, and does not connect the communication party terminal using the proximity wireless communication to the wireless communication device when the communication party terminal receives the first beacon signal and, a position of the communication party terminal is located outside the communicable area of the proximity wireless communication, and connects the communication party terminal to the wireless communication device when the communication party terminal receives the first beacon signal and the position of the communication party terminal is located inside the communicable area of the proximity wireless communication; wherein

the beacon generator configured to, in operation, further generate a second beacon signal for a short range wireless communication having a communicable area of the short range wireless communication which is wider than the communicable area of the proximity wireless communication,

the beacon transmitter configured to, in operation, further transmit the second beacon signal in a second cycle,

the first beacon signal is transmitted when a transmission request signal for the first beacon signal is received from the communication party terminal which has received the second beacon signal,

the second beacon signal includes identifying information for the short range wireless communication,

the first beacon signal includes identifying information for the proximity wireless communication, and

the beacon transmitter transmits the first beacon signal by using a smaller transmission power and a shorter transmission cycle than those of the second beacon signal.

7. The wireless communication device according to claim **6**, wherein

the beacon generator configured to, in operation, generate the first beacon signal including transmission power information and communicable area definition information of the first beacon signal as the information related to the communicable area.

8. The wireless communication device according to claim **6**, further comprising

a communicable area deciding section configured to, in operation, estimate a distance to the communication party terminal by using the proximity wireless communication connection request signal and outputs position information of the communication party terminal.

9. A wireless communication method in a wireless communication terminal capable of performing a proximity wireless communication and a short range wireless communication having a communicable area wider than that of the proximity wireless communication, the wireless communication method comprising:

a step of receiving a second beacon signal for the short range wireless communication;

a step of connecting the wireless communication terminal to a communication party device which has transmitted the second beacon signal by using the short range wireless communication in accordance with a reception of the second beacon signal;

a step of deciding a position of the wireless communication terminal by using the second beacon signal or a communication signal of the short range wireless communication as a second decided result;

a step of informing the communication party device of a transmission request signal for a first beacon signal when the second decided result indicates the position of the wireless communication terminal is located in a proximity of the communicable area;

a step of receiving the first beacon signal for the proximity wireless communication transmitted from the communication party device, the first beacon signal including information related to the communicable area of the proximity wireless communication;

a step of deciding the position of the wireless communication terminal by using the first beacon signal as a first decided result; and

a step of using the first decided result of the position of the wireless communication terminal, and not connecting the wireless communication terminal to the communication party device using the proximity wireless communication when the wireless communication terminal receives the first beacon signal and, the first decided result indicates the position of the wireless communication terminal is located outside the communicable area of the proximity wireless communication, and connecting the wireless communication terminal to the communication party device by using the proximity wireless communication when the wireless communication terminal receives the first beacon signal and the first decided result indicates the position of the wireless communication terminal is located inside the communicable area of the proximity wireless communication.

10. A wireless communication method in a wireless communication device capable of performing a proximity wireless communication and a short range wireless communication having a communicable area wider than that of the proximity wireless communication, the wireless communication method comprising:

a step of generating a second beacon signal for the short range wireless communication;

a step of transmitting the second bacon signal in a second cycle;

a step of connecting a communication party terminal which has received the second beacon signal by using the short range wireless communication;

a step of generating a first beacon signal including information related to the communicable area of the proximity wireless communication;

a step of transmitting the first beacon signal in a first cycle when a transmission request signal for the first beacon signal is received from the communication party terminal which has received the second beacon signal;

a step of receiving a proximity wireless communication connection request signal for requesting for a connection to the proximity wireless communication from the communication party terminal which has received the first beacon signal; and

a step of using the proximity wireless communication connection request signal, not connecting the communication party terminal using the proximity wireless communication to the wireless communication device when the communication party terminal can receive the first beacon signal, but a position of the communication party terminal is located outside the communicable area of the proximity wireless communication, and connecting the communication party terminal to the wireless communication device by using the proximity wireless communication when the communication party terminal can receive the first beacon signal and the position of the communication party terminal is located inside the communicable area of the proximity wireless communication.

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